Consulting Assistance on Economic Reform II

REPORTS

Determinants of Inflation in the Bulgarian Economy

Tzvetan Tsalinski
Steven Kyle

HIID

Report E
October 2000

Determinants of Inflation in the Bulgarian Economy

Steven Kyle

And

Tzvetan Tsalinski

October 2000

Abstract

This paper presents a vector autoregression analysis of the determinants of Bulgarian inflation over the period from 1991 to 2000. Monthly data are available for the entire period and various combinations of money aggregates, interest rates and the exchange rate were considered in modeling the dynamics of inflation in the Bulgarian economy. Bulgarian inflation is shown to have undergone two radically different regimes over the past decade. The dividing point between the two is the spring of 1997 when the hyperinflationary trends of the prior period were ended by the institution of a currency board. Inflation during the prior period is determined predominantly by monetary growth and to some extent by past inflation. Inflation after the institution of the currency board is no longer as dependent on monetary growth, while impulse response functions for the latter period clearly show the negative response of monetary authorities to price increases. In contrast, impulse response functions for the pre-currency board period demonstrate the explosive nature of the inflationary process, as monetary shocks cause the price level to grow without bound.

2

Introduction

This paper presents a vector autoregression analysis of the determinants of Bulgarian inflation over the period from 1991 to 2000. Monthly data are available for the entire period and various combinations of money aggregates, interest rates and the exchange rate were considered in modeling the dynamics of inflation in the Bulgarian economy.

This effort grew out of interest in Bulgaria in the construction of a leading indicator for inflation. This analysis shows that such an indicator is not possible- inflation responds rapidly to shocks to money aggregates, and cannot be shown to be responsive in any significant way to other variables. Moreover, rapidity of the response shows that a long-leading indicator cannot be constructed since inflation responds to monetary shocks within a month of their occurrence. Hence, any attempt to interpret past data would be rendered irrelevant before it could be calculated and disseminated.

One interesting aspect of the results is the difference between monetary behavior before and after resolution of the monetary /financial crisis of 1997. The explosive behavior of the response functions prior to that time are a testament to the hyperinflationary forces operating by the end of the period in the Spring of 1997. The rigid adherence of authorities to a zero inflation goal after the institution of the currency board in 1997 is also evident in the results.

The Vector Autoregression (VAR) and Vector Error Correction (VEC) models used are sufficiently well known so as not to require extensive discussion here. (See for example, Said & Dickey 1984, Johansen 1991, Johansen 1995 and Hamilton 1994.) All data proved non-stationary and required differencing in order to generate stationary series for estimation. Cointergrating relationships were found between money and inflation, confirming the obvious empirical observation that these two variables were closely linked

over the estimation period while they experienced radical changes in levels during the hyperinflationary episode.

Determinants of Changes in the Price Level

There are a variety of candidate series which can be considered as determinants of inflation, among them various money aggregates, interest rates, the exchange rate, foreign inflation, and assets of the currency board. However, by far the most important potential candidate is the quantity of money. While the precise aggregate to be used can be debated (M1, M2 and M3 are available in Bulgaria), as a practical matter all of the aggregates in Bulgaria are highly correlated, with results highly similar regardless of which aggregate is used.

All data series were obtained from data banks at the Bulgarian Agency for Economic Analysis and Forecasting. The origin of the data is the Bulgarian National Bank, the country's central bank. Monthly data were available from June of 1991 through May of 2000.

The analysis focused on M3 and inflation (measured by the Consumer Price Index). As noted above, similar results are obtained regardless of which monetary aggregate is used. It was therefore decided to use the broadest measure of money, M3. The CPI was the best available measure of inflation since, in spite of some changes in its calculation over the years, it is nevertheless the best and most consistent measure of inflation available. It was obvious that there had been a significant regime change with the institution of the currency board in Spring 1997. Accordingly the monthly data series was divided into pre and post-currency board periods and separate analyses were carried out on each period.

The raw data were tested for stationarity in logged form and Augmented Dickey-

4

Fuller tests indicated that the inflation series exhibited integration of order I while the

money series exhibited integration of order 2. A Johansen test for cointegration showed that these

series were indeed cointegrated and further analysis proceeded on this basis. (See Tables 1-3 for

the period 1991-1997 and Tables 4-6 for 1997-2000). The ordering
of the variables chosen was (M3,INFL) since these results demonstrated obviously

superior ability to explain the variation in the data as well as being in accord with prior beliefs as

to the nature of the inflationary process in Bulgaria.

The results for the Vector **Error Correction Models for each of the periods**
involved emphasize the fact that inflation is highly dependent on money and inflation

developments one and two periods before, making it impossible to develop a **reliable**
long-leading indicator at the present time. However, the results did reveal some

interesting patterns, reflecting the radically different mechanisms at work in Bulgaria over the two

periods involved. (See Tables 7 **and** 8 **for results of estimation** of the **VEC**
models.)

Figures 1 **and** 2 **show impulse response functions and the variance decomposition**
for the first period from 1991 -1997. The explosive nature of inflation is evident in the
impulse response functions in the earlier period, which reflect the inertial and unstable

nature of the process at work during that time. Inflation is seen to grow without bound in response

to shocks in money and past inflation, an accurate characterization of the path
inflation took over this period. The variance decomposition demonstrates that in the

very short run, inflation is highly dependent on its past value, showing that it is inertial (i.e. it is

feeding upon itself), while in the long run money growth is responsible for by far
the greatest percentage of the variance in price growth.

In **contrast, the second period shows** a **radically different pattern, with inflation**

responding quickly to past shocks, but rapidly returning to trend after a few periods. Figure 3

shows the impulse response functions for the 1997-2000 period where it can be

seen that though the response takes as much as a year to be completed, the majority of the adjustment is complete within 6 months of the initial shock. In addition, the quick response of monetary authorities to any rise in prices can be seen in the negative response of money to inflation in the upper right panel of Figure 3. The variance decomposition in Figure 4 reflect the essentially non-inflationary nature of currency board policy during this period with money variance accounting for a far lower amount of inflation variance than in the earlier period (Figure 2).

Numerous experiments were undertaken with other potential determinants of inflation, most notably the exchange rate and various interest rates. While some of these variables could be shown to be correlated with either money or inflation, none of them proved to be at all important in terms of explaining future changes in the price level. Figure 5 shows the results of one of these experiments, using the interest rate on government securities . This "basic interest rate" was significant in cointegrating equations with money and inflation, but the variance decomposition in Figure 5 shows that it had a near zero share in the variance decomposition of inflation during the 1997-2000. This is in line with results for other variables as well as for the earlier period (results not shown).

Conclusions

Bulgarian inflation has been shown to have undergone two radically different regimes over the past decade. The dividing point between the two is the spring of 1997 when the hyperinflationary trends of the prior period were ended by the institution of a currency board. Inflation during the prior period is determined predominantly by monetary growth and to some extent by past inflation. Inflation after the institution of the currency board is no longer as dependent on monetary growth, while impulse response functions for the latter period clearly show the negative response of monetary authorities to price increases. In contrast, impulse response functions for the pre-currency board

6

period demonstrate the explosive nature of the inflationary process, as monetary shocks cause the price level to grow without bound.

References

Hamilton, D. (1994) *Time Series Analysis* Princeton University Press

Johansen, S. (1991) "Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Autoregressive Models" *Econometrica* 59, pp. 1551-1580.

Johansen, S. (1995) *Likelihood Based Inference in Cointegrated VectorAutoregressive Models* Oxford University Press.

Said, S. & D. Dickey (1984) "Testing for Unit Roots in Autoregressive Moving Average Models of Unknown Order" *Biometrika* 71, pp. 599-607.

Table 1

1991-1997

Augmented Dickey-Fuller Unit Root Test on D(LOG(M3),2)

ADF Test Statistic	-0.810381	1% **Critical Value***	-3.5267 -2.9035
		5% Critical Value 10%	-2.5889
		Critical Value	

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-FuJler Test Equation
Dependent Variable: D(LOG(M3),3)
Method: Least Squares
Date: 06/22/00 Time: 14:37
Sample(adjusted): 1991 :06 1997:02
Included observations: 69 after adjusting endpoints

Variable	Coefficient	Std. **Error**	t-Statistic	Prob.
D(LOG(M3(-1 »,2)	-0.160260 -	0.197759	-0.810381 -	0.4207
D(LOG(M3(-1»,3)	0.387121 -	0.161730	2.393618 -	0.0196
D(LOG(M3(-2»,3)	0.178746	0.121088	1.476169	0.1447
C	0.004252	0.003896	1.091159	0.2792

R-squared	0.275852 Mean dependent var 0.242430	0.001374
Adjusted R-squared S.E.	S.D. dependent var 0.031895 Akaike info	0.036645
of regression Sum squared	criterion 0.066124 Schwarz criterion	-3.996504
resid Log likelihood	141.8794 F-statistic	-3.866991
Durbin-Watson stat	1.797126 Prob(F-statistic)	8.253573
		0.000099

Table 2
1991-1997

Augmented Dickey-Fuller Unit Root Test on D(LOG(INFL),2)

ADF Test Statistic	-0.766427	1% **Critical Value***	**-4.0948 -**
		5% **Critical Value** 10%	**3.4749** -
		Critical Value	3.1645

*MacKinnon critical values for rejection of hypothesis of a unit root.

I

Augmented Dickey-Fuller Test Equation Dependent
Variable: D(LOG(INFL),3)
Method: Least Squares
Date: 06122/00 Time: 14:41
Sample(adjusted): 1991:061997:02
Included observations: 69 after adjusting endpoints

Variable	Coefficient	Std. **Error**	t-Statistic	Prob
D(LOG(INFL(-1 »,2)	-0.294704 -	0.384516	-0.766427 -	0.4462
D(LOG(INFL(-1 »),3)	0.080033	0.217687	0.367650	0.7143
D(LOG(INFL(-2»,3)	0.443843 -	0.184732	2.402639 -	0.0192
C	0.039420	0.028318	1.392064	0.1687
@TREND(1991 :01)	0.001291	0.000648	1.991728	0.0507

R-squared	0.143609 Mean dependent var 0.090085	0.012748
Adjusted R-squared S.E.	S.D. dependent var 0.101172 Akaike info	0.106062 -
of regression Sum squared	criterion 0.655091 Schwarz criterion	1.674283 -
resid Log likelihood	62.76277 F-statistic	1.512392
Durbin-Watson stat	1.429138 Prob(F-statistic)	2.683066
		0.039205

Table 3

1991-1997

Johansen Cointegration Test

Date: 06/22/00 Time: 14:44
Sample: 1991 :01 1997:02
Included observations: 71
Test assumption: Linear deterministic trend in the data Series:
LOG(M3) LOG(INFL)
Lags interval: 1 to 2

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.454210	45.60659	15.41 3.76	20.04	**None ** At**
0.036155	2.614572		6.65	*most* 1

*(**) denotes rejection of the hypothesis at 5% (1 %) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LOG(M3) -   **LOG(INFL)** 1.107826
1.395549   -0.471313
0.779494

Normalized Cointegrating Coefficients: 1 **Cointegrating Equation(s) -**

LOG(M3}   **LOG(INFL)** -0.793829   c
1.000000   (0.01375)   -6.459450

Log likelihood   257.8211

Augmented Dickey-Fuller Unit Root Test on D(LOG(M3),2)

ADF Test **Statistic**	-14.19966	1% **Critical Value***		-3.6228
		5% Critical Value 10%		-2.9446
		Critical Value		-2.6105

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation Dependent
Variable: D(LOG(M3),3)
Method: Least Squares
Date: 06/22/00 Time: 12:23
Sample(adjusted): 1997:052000:04
Included observations: 36 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob
D(LOG(M3(-1»,2)	-1.280070	0.090148	-14.19966	0.0000
D(LOG(M3(-1»,3)	0.281700	0.066654	4.226298	0.0002
C	-0.002450	0.004196	-0.583871	0.5633

R-squared	0.859393	Mean dependent var S.O.		0.006322
Adjusted R-squared	0.850872	dependent var Akaike info		0.063943
S.E. of regression Sum	0.024693	criterion Schwarz criterion		-4.484943 -
squared resid Log	0.020121	F.statistic Prob(F.statistic)		4.352983
likelihood Durbin-	83.72897			100.8486
Watson stat	2.010633			0.000000

Table 5

1997-2000

Augmented Dickey-Fuller Unit Root Test on D(LOG(INFL»

ADF Test Statistic	-5.035108	1% Critical Value*	-3.6171
		5% Critical Value	-2.9422
		10% Critical Value	-2.6092

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOG(INFL),2)
Method: Least Squares
Date: 06/22/00   Time: 12:08
Sample(adjusted): 1997:04 2000:04
Included observations: 37 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(INFL(-1)))	-0.776689	0.154255	-5.035108	0.0000
D(LOG(INFL(-1)),2)	0.029885	0.020959	1.425893	0.1630
C	0.006486·	0.003289	1.971956	0.0568

R-squared	0.641304	Mean dependent var	-0.003363
Adjusted R-squared	0.620204	S.D. dependent var	0.029275
S.E. of regression	0.018042	Akaike info criterion	-5.114650
Sum squared resid	0.011067	Schwarz criterion	-4.984035
Log likelihood	97.62103	F-statistic	30.39383
Durbin-Watson stat	1.844934	Prob(F-statistic)	0.000000

Johansen Cointegration Test

Date: 06/22/00 Time: 12:40

Sample: 1997:032000:12

Included observations: 37

Test assumption: Linear deterministic trend in the data Series:

LOG(M3) LOG(INFL)

Lags interval: 1 to 2

Eigenvalue	Likelihood Ratio	5 Percent Crjtical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.506799	31.89873	15.41	20.04	None **
0.143832	5.745677	3.76	6.65	At most 1 *

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

L.R. test indicates 2 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LOG(M3)	LOG(INFL) -
1.316974	0.896228 9.822297
-3.182839	

Normalized Cointegrating Coefficients: 1 **Cointegrating Equation(s)**

LOG(M3)	LOG(INFL)	C
1.000000	-0.680521	**-12.22410**
	(0.94283)	

Log likelihood   205.7346

Table 7

1991-1997

Vector Error Correction Estimates

Date: 06/22/00 Time: 14:47 Sample(adjusted):
1991 :04 1997:02 Included observations: 71 after
adjusting
    endpoints
Standard errors & t-statistics in parentheses

Cotlltegrating Eq:	CointEq1	
LOG(M3(-1 »	1.000000	
LOG(INFL(-1}}	-0.793829 (0.01375) (-57.7445)	
C	-6.459450	

Error Correction:	D(LOG(M3»	D(LOG(INFL»
CointEq1	-0.284360 (0.03929) (-7.23780)	**-0.274867 (0.09936)** (-2.76643)
D(LOG(M3(-1»)	1.243735 (0.12287) (10.1225)	2.119847 (0.31073) (6.82220)
D(LOG(M3(-2»)	0.345099 (0.18078) (1.90892)	0.963225 (0.45719) (2.10684)
D(LOG(INFL(-1 »)	-0.359799 (0.10128) (-3.55249)	0.133346 (0.25613} (0.52061}
D(LOG(INFL(-2»))	-0.098226 (0.05458) (-1.79955)	-0.436155 (0.13804) (-3.15964)
C	0.010000 (0.00544) (1.83857)	-0.037326 (0.01375) (-2.71366)
R-squared	0.855166	0.796224
Adj. R-squared Sum	0.844025	0.780549
sq. resids S.E.	0.051516	0.329478
equation F-statistic	0.028152	0.071196
Log likelihood Akaike	76.75769	50.79568
AIC Schwarz SC	155.8683 -	89.99420 -
Mean dependent S.D.	4.221642 -	2.366034 -
dependent	4.030430	2.174821
	0.050623	0.078320
	0.071283	0.151981

| Determinant Residual Covariance Log	2.40E-06
Likelihood	257.8211 -
Akaike Information Criteria Schwarz	6.868200 -
Criteria	6.422038

Table 8

1997-2000

Vector Error Correction Estimates

Date: 06122/00 Time: 12:43 Sample(adjusted):
1997:04 2000:04 Included observations: 37 after
adjusting
   endpoints
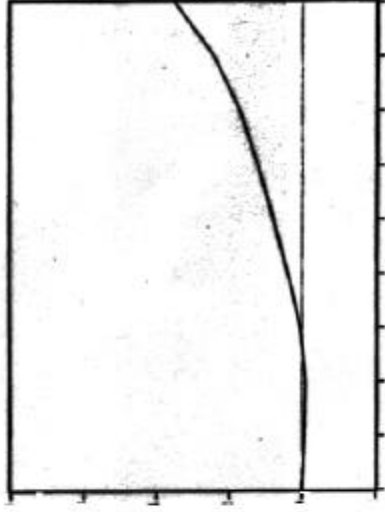Standard errors & t-statistics in parentheses

Cointegrating Eq	CointEq1	
LOG(M3(-1»	1.000000	
LOG(INFL(-1»	-0.680521 (0.94283) (- 0.72178)	
c	-12.22410	

Error Correction	D(LOG(M3»	D(LOG(INFL»
CointEq1	-0.159822 (0.02851) (- 5.60507)	-0.027592 (0.01663) (-1.65968)
D(LOG(M3(-1»)	0.580263 (0.11963) (4.85049)	0.185504 (0.06975) (2.65955)
D(LOG(M3(-2»)	**-0.085591** **(0.10368) (-** **0.82552)**	0.221572 (0.06045) (3.66527)
D(LOG(INFL(-1»)	-0.433334 (0.24748) (- 1.75096)	-0.190058 (0.14429) (- 1.31715)
D(LOG(INFL(-2»)	**-0.104560** **(0.04106) (-** **2.54642)**	-0.115248 (0.02394) (- 4.81384)
c	0.019959 (0.00471) (4.24144)	0.001290 (0.00274) (0.47003)

R-squared	0.716541	0.584540
Adj. R-squared Sum	0.670822	0.517530
sq. resids S.E.	0.014532	0.004940
equation F-statistic	0.021651	0.012624
Log likelihood Akaike	15.67267	8.723207
AIC Schwarz SC	92.58236 -	112.5432 -
Mean dependent S.D.	4,680128 -	5.759091 -
dependent	4.418898	5.497861
	0.022796	0.008031
	0.037737	0.018174

Determinant Residual Covariance Log	5.07E-08
Likelihood	205.7346 -
Akaike Information Criteria Schwarz	10.36403 -
Criteria	9.754495

Response One D novations
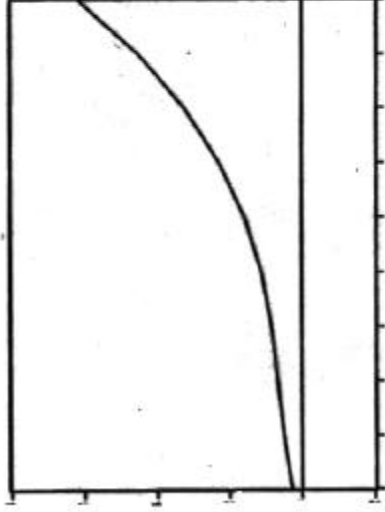
Response

esponse of OG(M3) to OG(/NI)

Response of LOG(/NI) to LOG(NFL)

esponse of OG(M) to LOG(M3

Response of OG(NFL) to OG(M3)
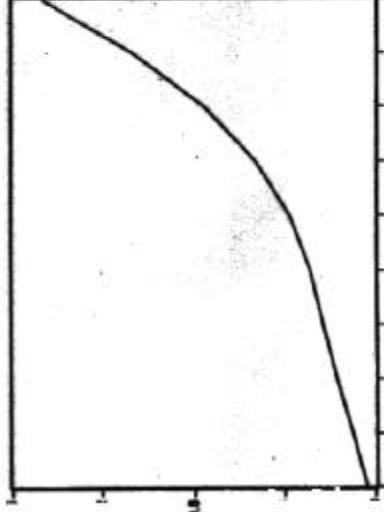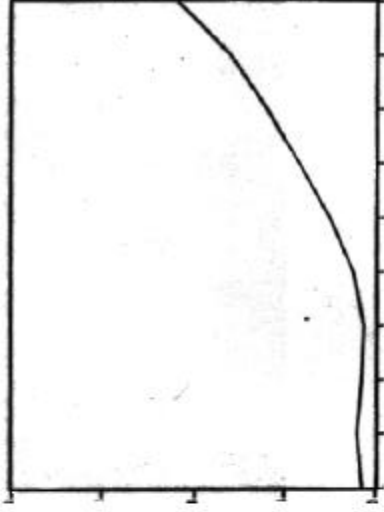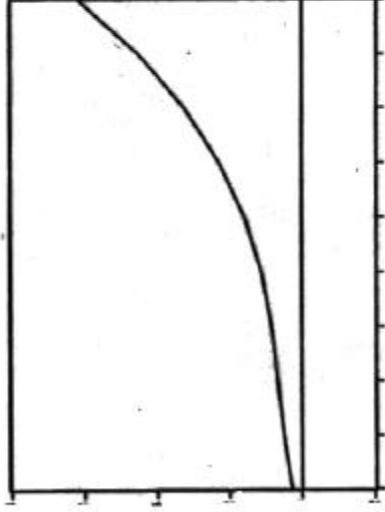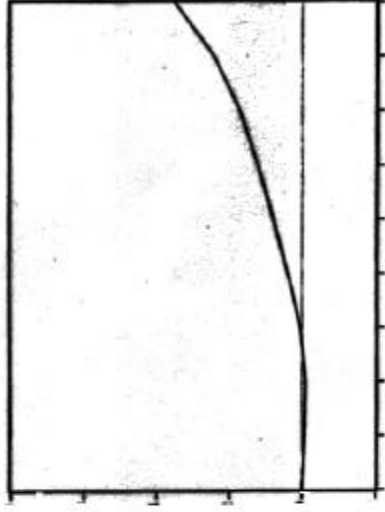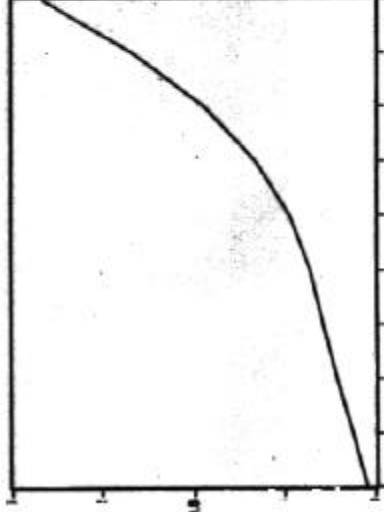
Figure
991-199

Response   One   D   novations

Response

esponse of OG(M) to LOG(M3

esponse of OG(M3) to OG(INI)

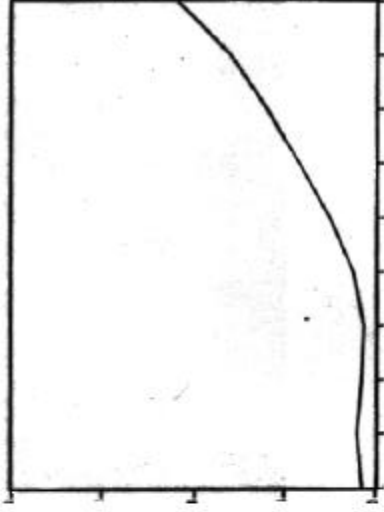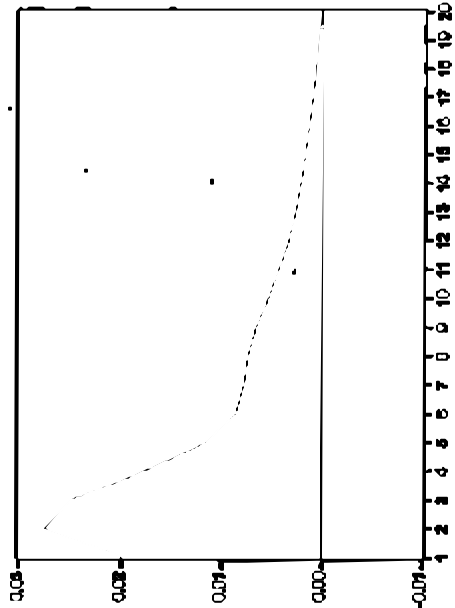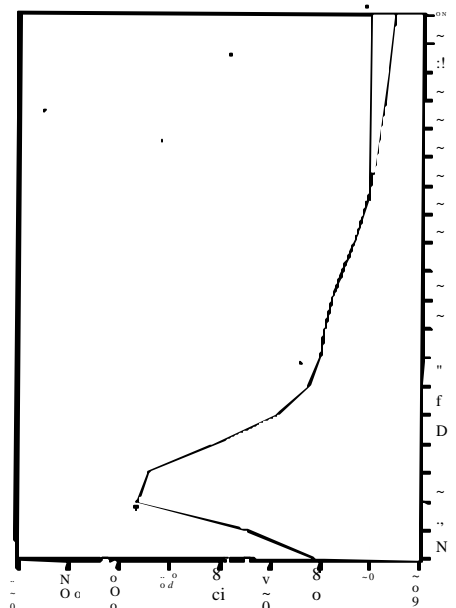Response of OG(NFL) to OG(M3)

Response of LOG(INI   to LOG(NFL)

Figure
991-199

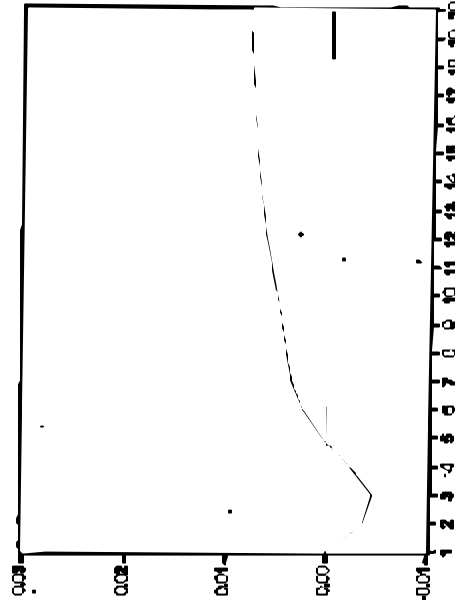Response of LOG(M3) to LOG(INFL)

Response of LOG(INFL) to LOG(INFL)

Response of LOG(M3) to LOG(M3)